Space Weather Technical Forecast

Issued on Monday, 13 December 2021 at 00:31 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of G1/Minor Geomagnetic Storms, mainly day 2 (14th)

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar Activity was Low, with one C1 flare observed from a new Bxo/Beta sunspot region that recently rotated onto the Earth-facing disc from around the southeast limb. Two further sunspot containing active regions have emerged on the Earth-facing side in the last 24 hours, AR2905 Cro/Beta in the southeast and a new unnumbered region Bxo/Beta in the northeast. Both remain small and simple. No Earth-directed CMEs have been observed in available imagery.

Solar Wind / Geomagnetic Activity: The solar wind speed, as measured by DSCOVR and ACE at L1, was at background, between 300 and 320 km/s throughout. Density, was around average until 12/1700 UTC before gradually increasing to be above average at around 20 ppcc. The Interplanetary Magnetic Field strength (IMF), Bt, was weak throughout, peaking at around 8 nT. The Bz component was variable, but mainly negative (southward pointing) ranging -5 nT to +4 nT. Phi angle was negative (towards the Sun) for much of the period, but exhibited a rotation to positive after 12/2000 UTC. Geomagnetic activity was Quiet (Kp 0-2).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) remained at Background levels. The high energy electron flux (greater than 2 MeV) was at Background to Moderate with the associated 24-hour integrated fluence persisting below the Active threshold, with 1.31e7 observed at 12/2100 UTC

Four-Day Space Weather Forecast Summary

Solar Activity: Solar Activity is expected to be Low to Very Low, with a 60% chance of further C-class flares from any of the emergent sunspot regions on the disc.

Solar Wind / Geomagnetic Activity: There are no Earth-directed CMEs. Background solar wind speeds could become slightly elevated to elevated day 1 (13th) from the arrival of fast wind from newly developed coronal hole 34, however confidence is low. A subsequent connection to CH32 fast wind is then expected to give elevated solar winds day 2 and 3, before easing back day 4. Quiet geomagnetic conditions at first, likely becoming Unsettled to Active for a period day 1 (13th), and then again but more persistently later day 2 (14th), and also with an increased chance of isolated G1/Minor Storms intervals. This risk decreasing day 3 (15th), with activity becoming Quiet with Unsettled intervals day 4 (16th).

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels. The high energy electron flux (greater than 2 MeV) is likely to vary between Moderate and Background levels at first with the associated 24 fluence persisting below the Active (1e8 integrated pfu) threshold. Any enhancement to the solar wind from CH34 and CH32, days 1 and day 2 or 3 respectively, is likely to increase flux, potentially reaching persistently High levels day 4, but with Low confidence. This giving a chance Active fluence by the end of day 4 (16th).

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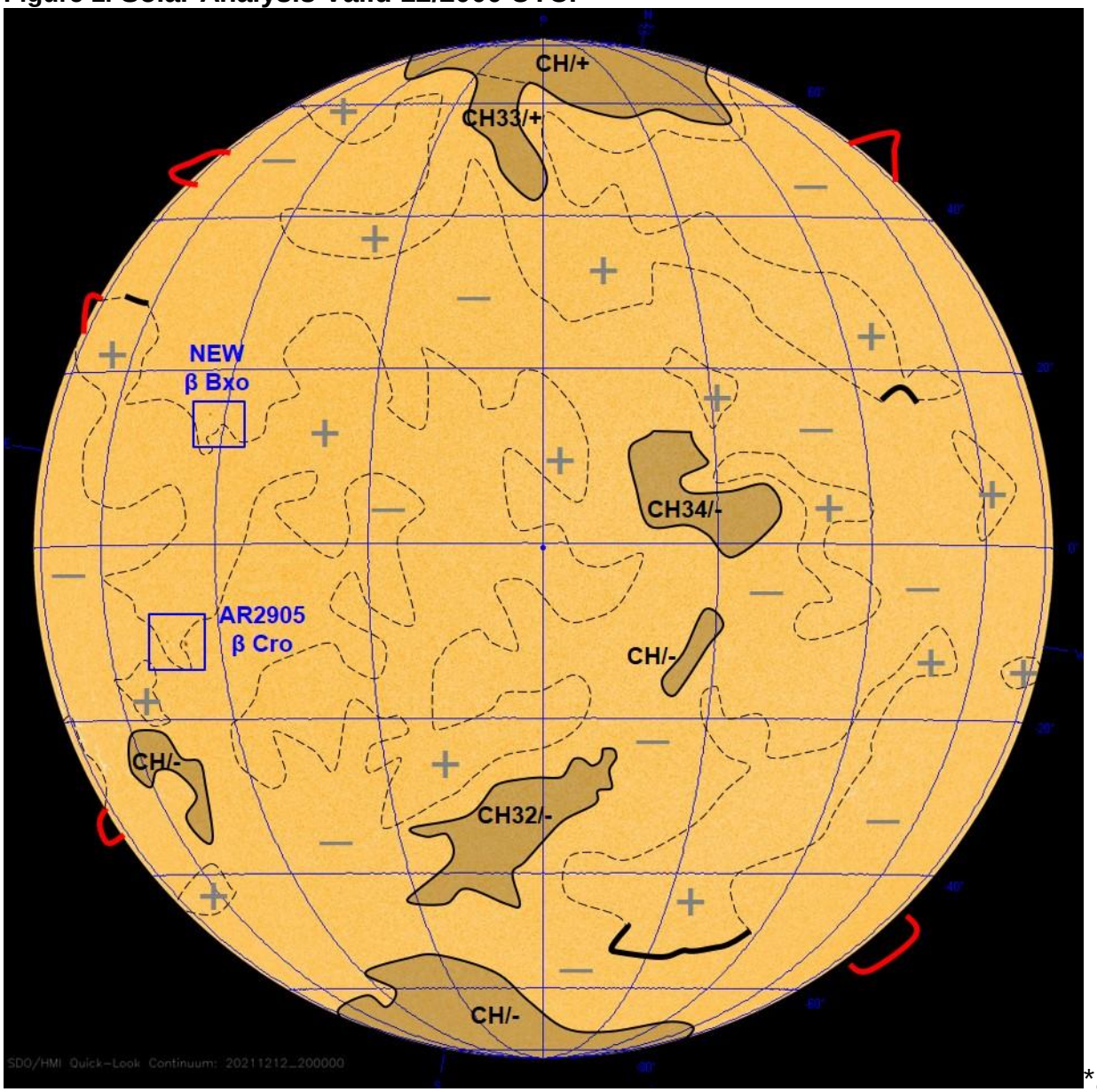
Figure 1. Solar Analysis Valid 12/2000 UTC.



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Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are no Earth-directed CMEs. Solar winds are currently at background, but exhibiting above average density. This is potentially due to heliospheric current sheet interactions ahead of a fast wind of a newly opened coronal hole, CH34/-, in the centre disc. STEREO A PLASTIC data, indicates a slight enhancement was observed for the equivalent day, and any subsequent fast wind has likely strengthened as this hole as opened. Consequently slightly elevated to elevated winds are expected day 1 (13th), 450-500km/s.

This is likely to be followed by a transition into the persistent CH32/- in the southern hemisphere. On the previous rotation this brought L1 speeds of 600km/s, and lead to a G1/Minor Storm interval. Despite some eastward retreat resulting in a later connection that persistence would suggest, a similar observed speed at L1 is possible, most probably late day 2 (14th) but potentially day 3 (15th). Solar winds are then likely to gradually ease day 4 (16th).

Quiet geomagnetic conditions at first, likely becoming Unsettled to Active for a period day 1 (13th), and then again but more persistently later day 2 (14th), and also with an increased chance of isolated G1/Minor Storms intervals. This risk decreasing through day 3 (15th), with geomagnetic activity gradually decreasing to Quiet with Unsettled intervals by day 4 (16th).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	30	20	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Figure 2: Solar Wind Persistence Model – Shows much earlier arrival of fast wind on last rotation compared to expected arrival on this occasion.

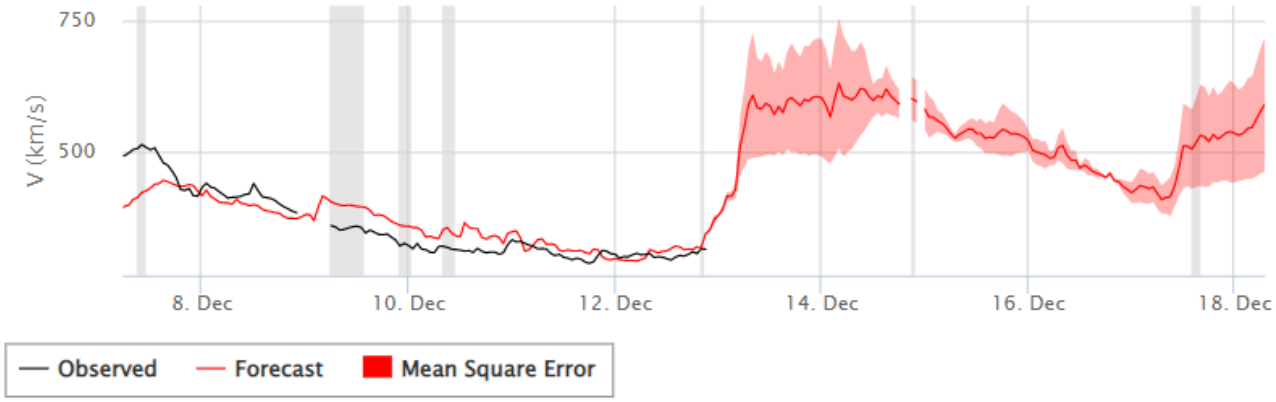

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Figure 3: SDO aia-193 of previous rotation (left) and current rotation (right). Eastward retreat of CH34 clearly visible.

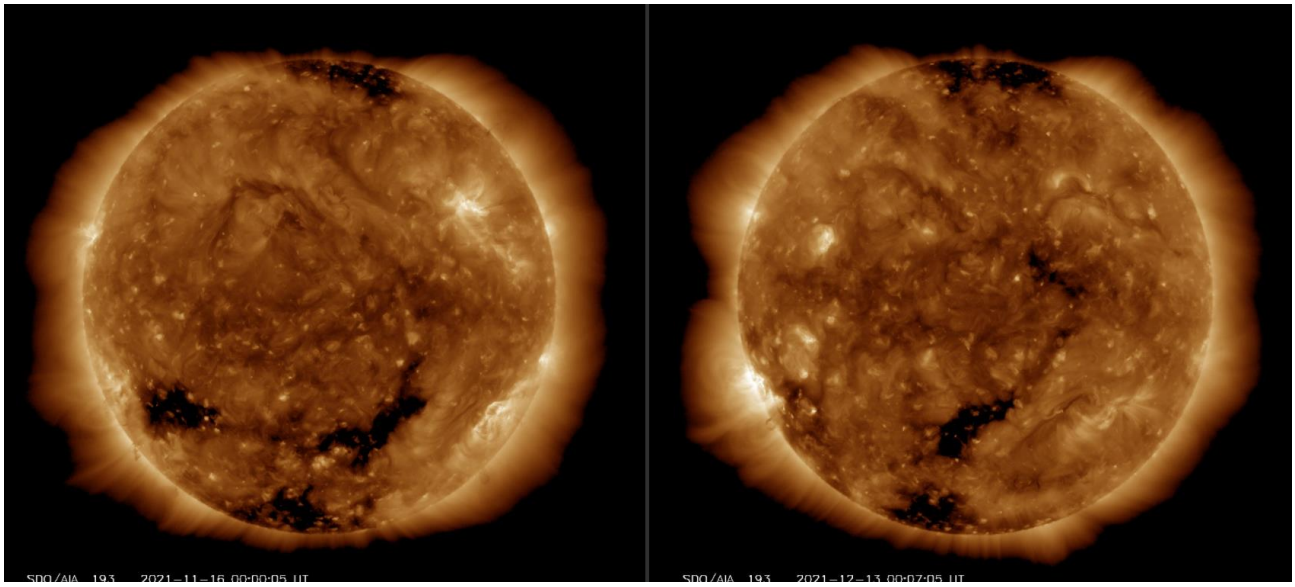
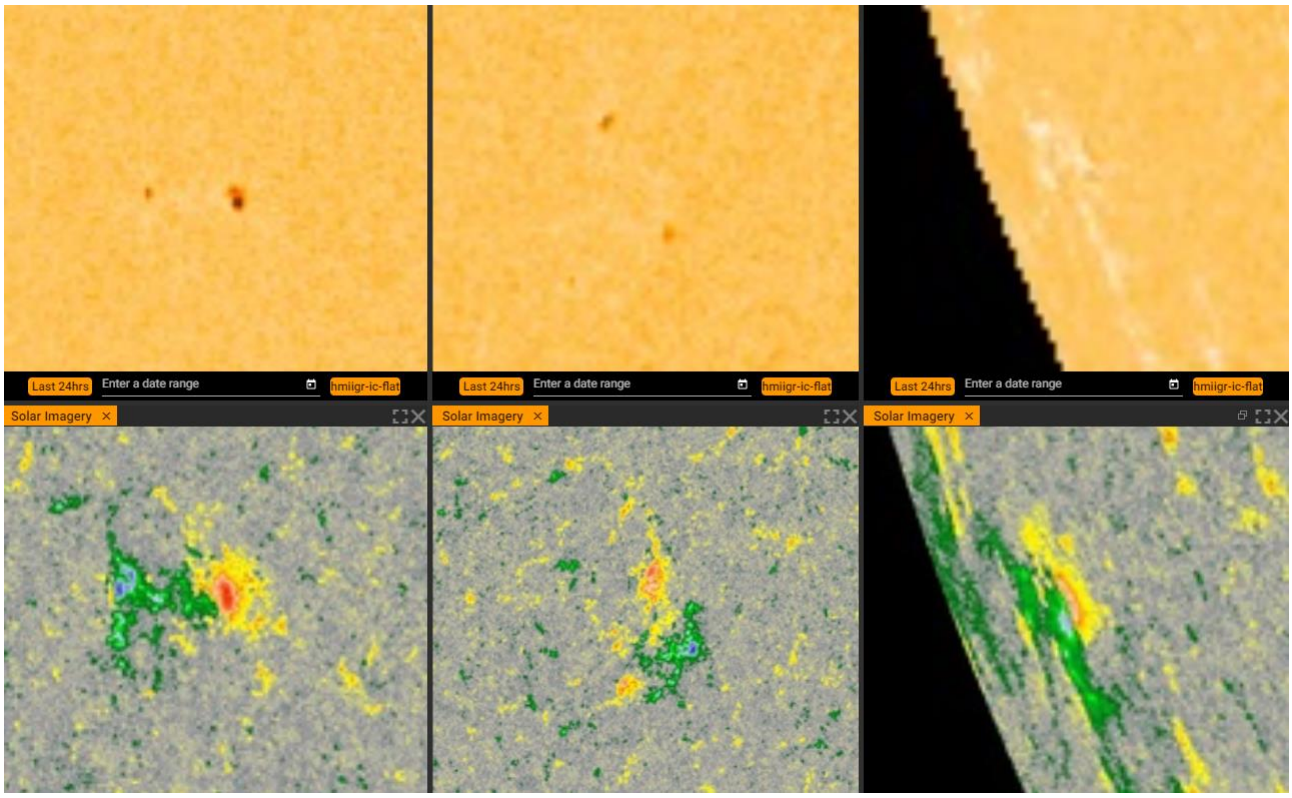


Figure 4: SDO Intensitygram (top) and associated Magnetogram (bottom) of 3 small and simple sunspots that emerged in the last 24 hours. Rightmost, whilst barely visible amongst plage was the source of the C1-flare



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Radio Blackouts - X-Ray Flares:

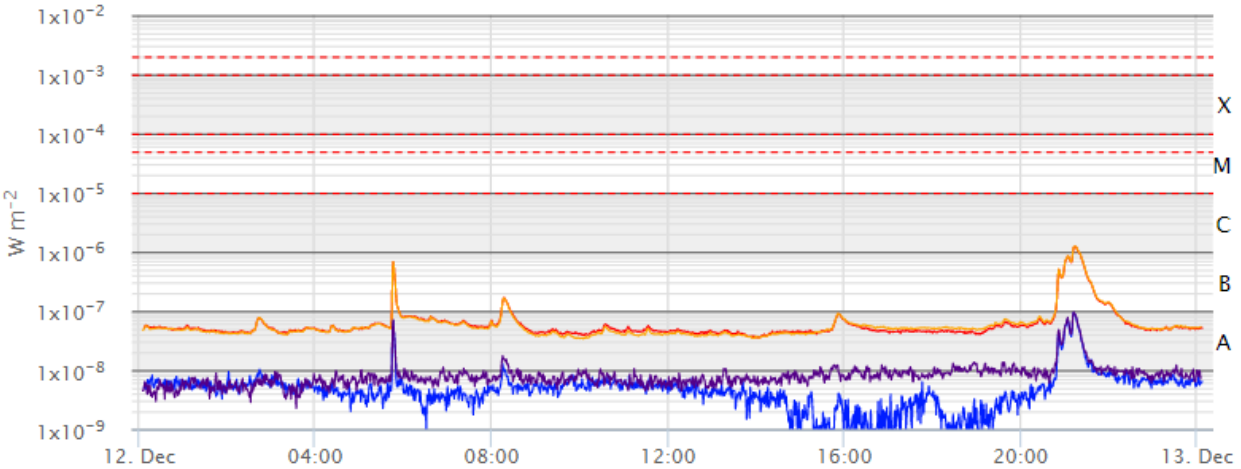
Solar Activity has recently increased to Low levels, with a C1-flare observed from a newly visible sunspot region on the southeast limb. This is still too close to the limb to allow a confident assessment, but has been preliminary analysed as a small Bxo/Beta region amongst plage,

There are two other sunspot containing active regions, all of which emerged in the eastern disc in the last 24 hours. AR2905 Cro/Beta is the largest region, but despite some ongoing development, remains small and simple with only a rudimentary penumbra currently visible. A yet to be numbered region Bxo/Beta has also emerged in the north.

Solar Activity is expected to continue at Low to Very Low levels, with a 60% chance of further C-class flares each day. The chance of increasing to Moderate is currently very low, but slightly increased above background (2%).

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	2	2	2	2
Very Active	R3 to R5 X Class	No	1	1	1	1

Figure 5: GOES-16/17 X-ray flux



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Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) as observed by GOES-16 is forecast to remain at background levels.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	1	1	1	1
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2 MeV) electron flux, as observed by GOES-16, is expected to generally be Background to Moderate with just a chance of reaching High (greater than 1000 pfu) at first. The arrival of the fast winds of CH34, potentially day 1 (13th), and then CH32 (14th), most likely day 2, has the potential to increase the flux with persistently High flux possible by late day 3 or day 4 (15th or 16th), although confidence is Low.

The associated 24 hour fluence is expected to persist below the Active level day 1 and day 2 (13th and 14th), but with an increasing chance of rising above by the end of day 4 (16th). This is supported by REFM which maintains fluence below the Active threshold.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	10	30
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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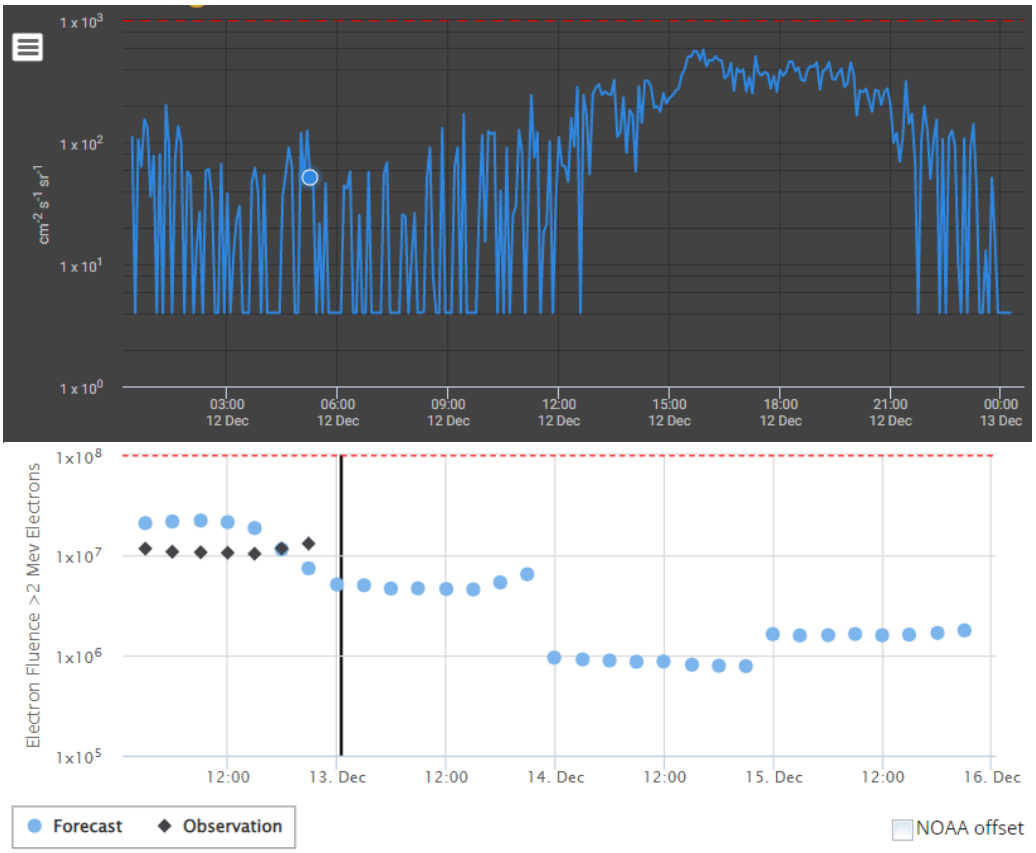
Figure 6: GOES-16 >2MeV Electron Flux and associated 24 hr fluence with REFM



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